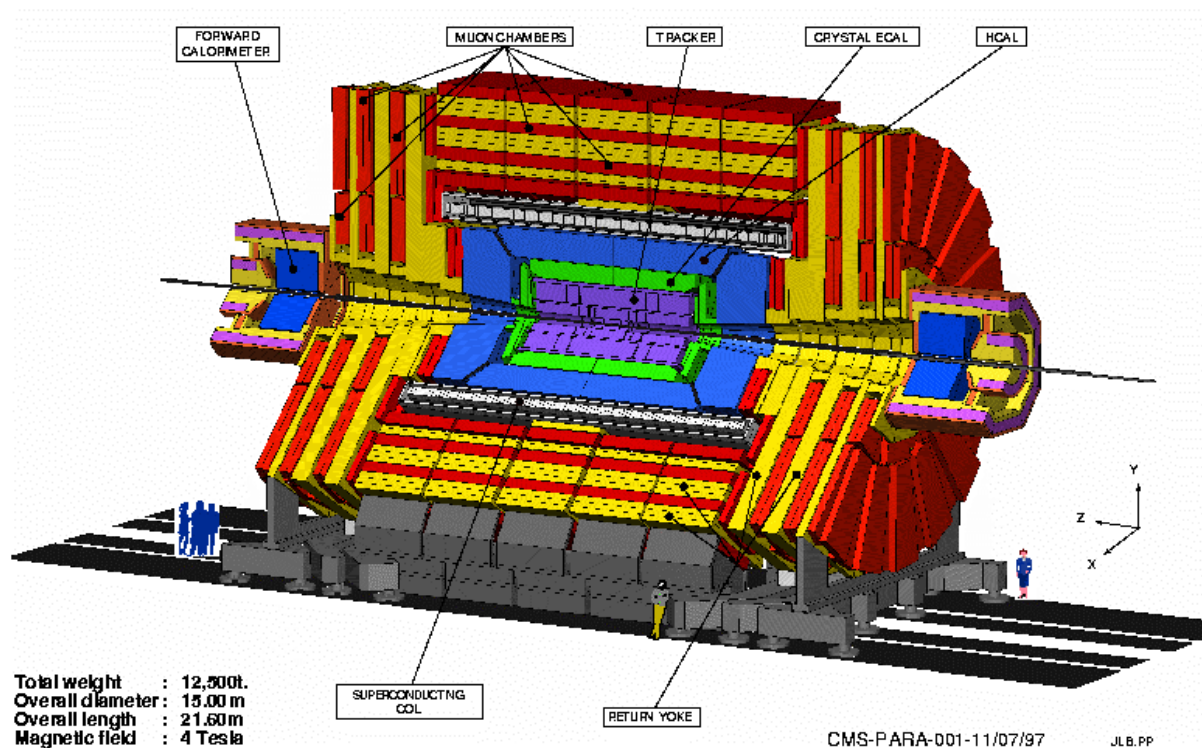




US CMS Project Management Plan



US CMS Project Management Plan

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US CMS

Project Management Plan

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LIST OF ABBREVIATIONS AND ACRONYMS

AAAP	Advance Acquisition or Assistance Plan
ACWP	Actual Cost of Work Performed
APP	Advance Procurement Plan
BAO	Batavia Area Office
BC	Budgeted Cost
BCCB	Baseline Change Control Board
BCWP	Budgeted Cost of Work Performed
BCWS	Budgeted Cost of Work Scheduled
CCB	Configuration Control Board
CD	Construction Directive
CDR	Conceptual Design Report
CERN	European Laboratory for Particle Physics
CH	Chicago Operations Office
CMS	Compact Muon Solenoid
CPM	Construction Project Manager
CPR	Cost Performance Report
CSCG	Cost/Schedule Controls Group
C/SCS	Cost and Schedule Control System
CSP	Cost and Schedule Plan
DAQ	Data Acquisition
DCC	Document Control Center
DHEP	Division of High Energy Physics
DOE	Department of Energy
EA	Environmental Assessment
EAC	Estimate at Completion
ECAL	Electromagnetic Calorimeter
ECR	Engineering Change Request
EMU	Endcap Muon System
ER	Office of Energy Research
ESAAB	Energy System Acquisition Advisory Board
ES&H	Environment, Safety and Health
FES	Facilities Engineering Services
FIFS	Fermilab Integrated Financial System
FNAL	Fermi National Accelerator Laboratory (Fermilab)
FONSI	Finding of No Significant Impact
FSAR	Final Safety Analysis Report
GeV	Giga-electron-Volt
HCAL	Hadron Calorimeter
HENP	High Energy and Nuclear Physics
JOG	Joint Oversight committee
L1	Level 1

L2M	Level 2 Manger
MAP	Mitigation Action Plan
MOU	Memorandum of Understanding
MRE	Major Research Equipment
MSA	Major System Acquisition
NSF	National Science Foundation
PMG	Project Management Group
PMP	Project Management Plan
PSAR	Preliminary Safety Analysis Report
PSWBS	Project Summary Work Breakdown Structure
QA	Quality Assurance
QAC	Quality Assurance Committee
QAP	Quality Assurance Plan
QC	Quality Control
R&D	Research and Development
SAR	Safety Analysis Report
SOW	Statement of Work
SQIP	Specific Quality Implementation Plan
TD	Technical Director
TEC	Total Estimated Cost
TeV	Tera-electron-Volt
TPC	Total Project Cost
URA	Universities Research Association
WBS	Work Breakdown Structure

Section I

Introduction

I. Introduction

This Project Management Plan (PMP) sets forth the specific plans, organization, responsibilities and systems to be used in managing the work necessary for successful completion of the US Compact Muon Solenoid (CMS) construction project. Fermilab will provide management oversight for this project lead by the Fermilab Deputy Director. This project includes the construction of elements of the CMS detector for which the US groups collaborating on CMS take responsibility. A US CMS Project Office has been formed and has been charged with meeting the technical, cost, and schedule objectives of the US CMS Project. The project will have its management office at Fermilab, in Batavia, Illinois. Fermilab is a DOE Laboratory operated under contract DE-AC02-76-CH-03000 by the Universities Research Association, Inc. (URA). DOE, NSF, Fermilab and the US CMS Collaboration will work together as a team to accomplish the US CMS Project.

The US groups will participate in the building of the Compact Muon Solenoid (CMS) experiment which is designed to study the collisions of protons on protons at a center of mass energy of 14 TeV at the Large Hadron Collider (LHC) at CERN. To enable studies of rare phenomena at the TeV scale, the LHC is designed to operate at a luminosity of $10^{34} \text{ cm}^{-2} \text{ s}^{-1}$. The physics program includes the study of electroweak symmetry breaking, investigation of the properties of the top quark, searches for new heavy gauge bosons, probing quark and lepton substructure, looking for supersymmetry and exploring for other new phenomena.

The US CMS Group agrees to take leadership responsibility in the CMS experiment for the endcap muon system, and for all hadron calorimetry, as well as associated aspects of the trigger and data acquisition system. The US CMS Collaboration also plans to work on important areas of electromagnetic calorimetry, tracking, and common projects. These common projects will be provided as in kind contributions wherever possible.

A. US CMS Project

The US CMS Collaboration is part of CMS. CMS is a collaboration of high energy physicists from many nations which will conduct an experimental investigation of the interactions of protons on protons at a center of mass energy of 14 TeV at the Compact Muon Solenoid (CMS) experiment planned for the Large Hadron Collider (LHC) at CERN. The CMS detector is designed to exploit the full range of physics at the LHC up to the highest luminosities.

There are two systems where the US has overall responsibility and they are endcap muon (EMU) system and the hadron calorimeter (HCAL) system. US CMS groups will take construction responsibility for these and other items. The US will design the endcap steel, which will be constructed as a CMS common project. The hadron calorimetry is managed by US groups. The US groups will build the barrel, supply the endcap transducers and front-end electronics, and build half of the forward system while maintaining complete HCAL management responsibility. In addition, since the HCAL is supported by the solenoid cryostat, US groups are involved in the design of the cryostat and intend to construct elements of it as a CMS Common Project.

For the other subsystems, the US responsibilities are not global. However, in every case they are focused on particular area of US expertise. For example, US groups have overall CMS trigger management responsibility and will do essentially all endcap muon level 1 triggers, all calorimeter level 1 triggers, the event builder switch and the Data Acquisition (DAQ) output filter units. In EM calorimetry the US focus is on transducers, front end electronics and monitoring. In tracking the US groups will build all the endcap silicon pixels.

B. Project Management Plan

The PMP presents the top level technical, cost, and schedule baselines for the US CMS Project, and sets forth the organization, systems, and plan by which the project participants will manage the US CMS Project. The line of authority at the top levels of the US CMS Project is shown in Figure I-1.

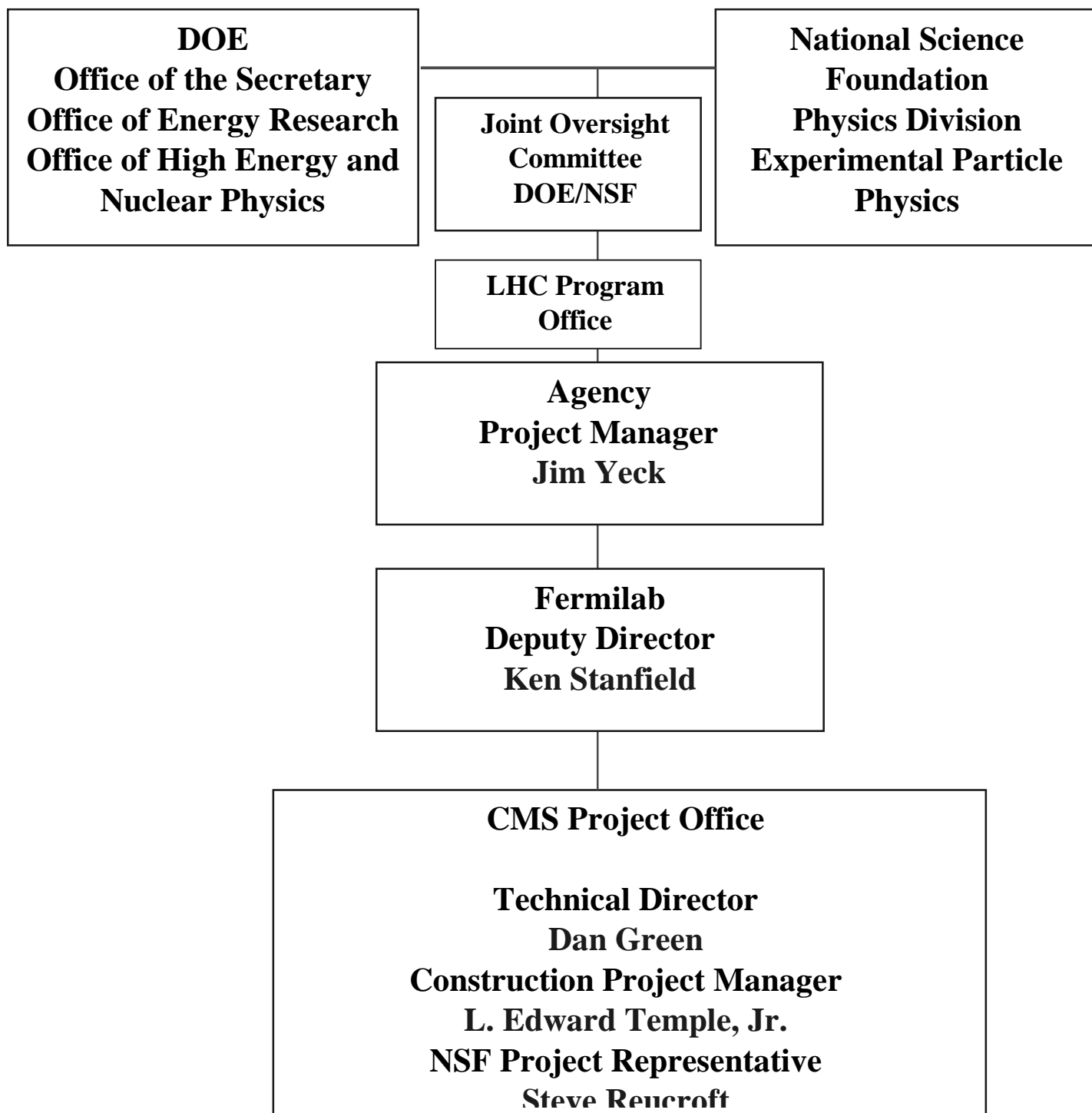
The management approach described here is based on ER and NSF experience with projects to construct complex detectors designed as research tools to advance the frontiers of knowledge. Three fundamental principles underlie the development of the organizational structure, the assignment of roles and responsibilities, and the implementation of management systems to optimize the success of the project. These principles are:

- a. The US CMS Technical Director (TD) and Construction Project Manager (CPM) are jointly appointed by DOE, NSF, and Fermilab with input from the US CMS Collaboration. The US CMS TD has the technical responsibility for the successful achievement of the performance goals while working closely with the CPM who has responsibility to complete the project within the cost and schedule objective.
- b. Relevant formal management systems and requirements are implemented to aid in achieving the project goals and to account properly for the use of public funds. Fermilab has management oversight responsibility for the US CMS Project. To accomplish the oversight function, Fermilab will convene a Project Management Group (PMG) which will act as a high level change control board for the US CMS Project.

- c. Project Management incorporates a team approach involving DOE ER, NSF, Fermilab,
and US CMS.

Following this introductory section, Section II provides an overview of the US CMS Project, the design goals, scope and objectives. The roles and responsibilities of the major project participants are defined in Section III. Section IV through VII describe the work and its organization and the associated cost, schedule, and technical baselines. A discussion of the system that will be used to manage and control cost and schedule and to measure the technical performance of the project is given in Section VIII. Reporting requirements and review procedures are described in Section IX.

This plan will be reviewed and revised, as required, to reflect new project developments and/or other agreements among the participants. Revisions, as they are issued, will be signed by all participants, and will supersede in their entirety previous editions. To the extent that there are inconsistencies or conflicts between this plan and the terms and conditions of applicable laws, regulations, and contracts, the provisions of those documents shall prevail over this plan.



LINE OF AUTHORITY AT THE TOP LEVELS OF THE US CMS PROJECT

FIGURE I-1

SECTION II

Project Objectives

II. Project Purpose

A. Project Objectives

The purpose of the US CMS Project is to enable US high energy physicists to participate in research at the high energy frontier available at the Large Hadron Collider (LHC) at CERN.

The US CMS project is described in the US CMS Letter of Intent of September 8, 1995 and in the US CMS Project Status Report of October 15, 1996, and is outlined below. US responsibilities within CMS include both management and construction.

US groups have management responsibility for the endcap muon system, the hadron calorimeter, and the trigger. Construction responsibilities within the US extend to portions of all five CMS subsystems: Muon, Hadron Calorimeter, Trigger/DAQ, Electromagnetic Calorimeter, and Tracking. In addition, there is US participation in the Common Projects and the costs of the Project Office at Fermilab are explicitly called out. Hence, there are seven WBS level 2 categories, as discussed in Section V.

B. Technical Objectives

US CMS responsibilities in the muon system are for construction of the endcap muon chambers. US CMS responsibilities in the HCAL system are for construction of the entire barrel, the endcap transducers and readout, and roughly half of the forward system - concentrating on transducers and readout. US physicists also have responsibilities within the CMS trigger and data acquisition system. US CMS groups will construct the level 1 calorimeter and endcap muon trigger and the level 2 event builder switch and the output event filter. US CMS responsibilities in ECAL are to provide some of the transducers, front end electronics, and monitoring systems. The US groups involved in CMS tracking will provide all the forward pixel disks.

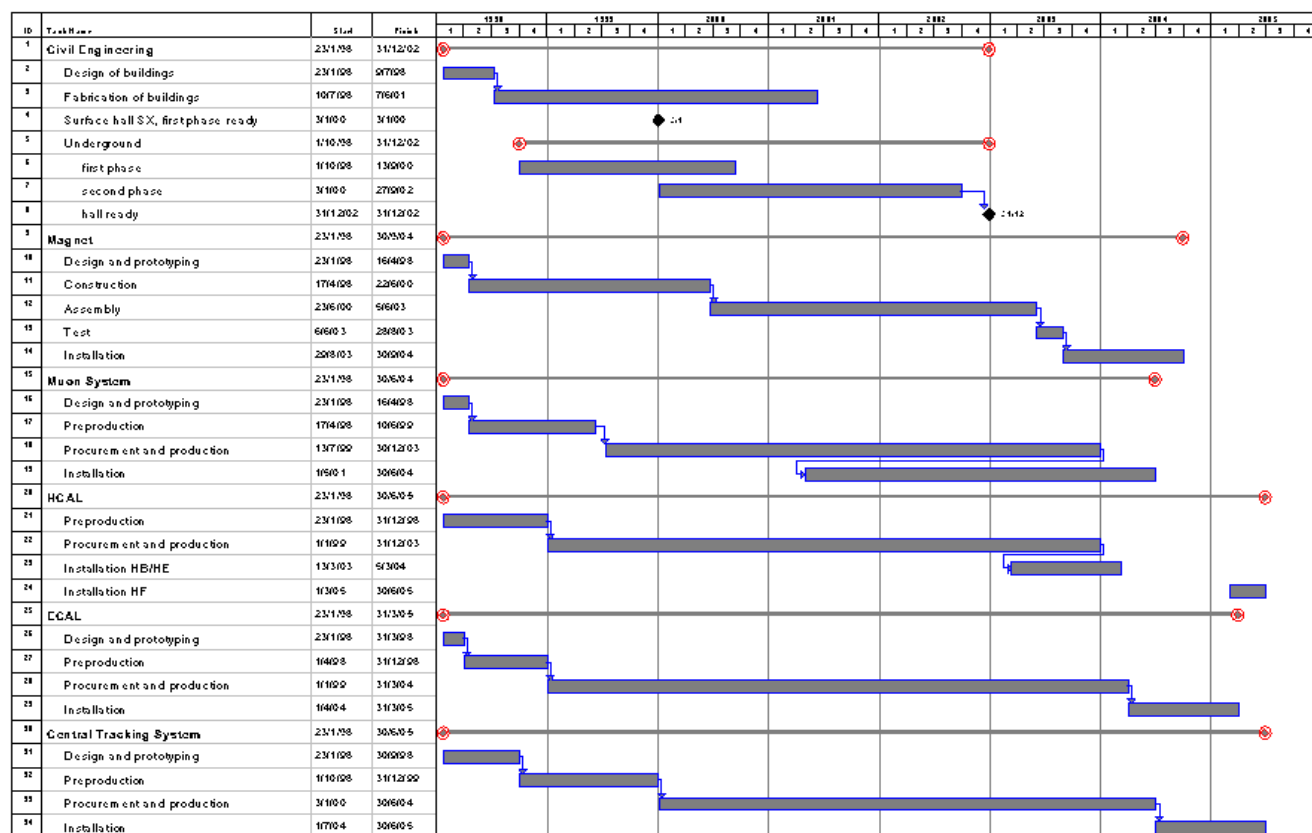
C. Schedule Decision Points

The key milestones for the project are shown in the CMS Construction Schedule, Fig. II-1. This overall CMS schedule must be supported by the US CMS Project schedule in that the US groups are responsible for a subset of the experimental apparatus. Both the schedule and cost are, of course, dependent on the rate of funding. This schedule results from discussions between CERN, CMS, DOE/NSF and US CMS. A more detailed schedule is given in Section VI. A US CMS Level 1 (L1) schedule is derived from, and is consistent with, the overall CMS planning. The level 2 managers then create a level 2 schedule which is tied to the level 1 milestones.

D. Cost Objectives

The Total Project Cost (TPC) for construction of the US CMS Project is \$167.2M in then year dollars. The cost estimate is summarized in Table II-1. Detailed discussion of the cost estimates, together with obligations and cost profiles based on schedules described in Section VI, are presented in Section VII.

CMS Construction Schedule



27 April 1998

CMS CONSTRUCTION SCHEDULE

FIG. II-1.

WBS Number	Description	Total Cost (k\$)
US CMS Total Project Cost (then-year dollars)		\$167,245
	Escalation (DOE January 1998 indices)	\$14,485
	FY97 R&D	\$4,640
	FY96 R&D (FY97 dollars)	\$2,364
US CMS Total Estimated Cost (FY97 dollars)		\$101,976
1	Endcap Muon	\$24,190
2	Hadron Calorimeter	\$27,624
3	Trigger and Data Acquisition	\$10,915
4	Electromagnetic Calorimeter	\$7,153
5	Forward Pixels	\$4,677
6	Common Projects	\$22,249
7	Project Office	\$5,170
	Contingency	\$43,779

US CMS PROJECT COST ESTIMATE

TABLE II-1

Section III

Project Organization and Responsibilities

III. Project Organization and Responsibilities

A. DOE and National Science Foundation (NSF) Organization and Responsibilities

The Department of Energy and the National Science Foundation have established the need for the US CMS Project by considering and responding to advice from their advisory panels, and in negotiations with CERN. The Department of Energy and the National Science Foundation (NSF) provides the majority of the funding for the US CMS Project. The DOE Division of High Energy Physics and the NSF Physics Division provide annual program guidance to US CMS and to the host laboratory as well as annual guidance on the funding profile for the project. The DOE and NSF exercise oversight of the project by:

- 1 conducting reviews of the project;
- 1 participating in regularly scheduled Project Management Group (PMG) meetings;
- 1 monitoring project progress via quarterly progress reports; and
- 1 monitoring milestones/performance measures.

B. Joint Oversight Group (JOG)

The partnership between the DOE and NSF will be implemented through a Joint Oversight Group (JOG). This includes their relations with the US CMS Project Office and the Fermilab Directorate. The JOG consisting of the Head of the Physics Division at the NSF and the Head of High Energy Physics Division at the DOE and their designees. Since the two agencies are in partnership for US CMS, such a committee is mandatory. The US CMS Construction Project Manager (CPM) directly to the Fermilab Deputy Director and through him to the Agency Project Manager. In addition, a key responsibility of the Construction Project Manager is to provide the budget request and to recommend to the JOG, with the concurrence of Fermilab, allocation of the annual budget among the participating institutions. The CPM interacts with Fermilab as appropriate on all matters having to do with managing the project to the agreed scope, within cost and schedule.

C. Fermilab Director

The Fermilab Director has the overall responsibility to the Department of Energy and the National Science Foundation for the management oversight of the US CMS Project. The Fermilab Director has delegated certain responsibilities and authorities to the Deputy Director. Management oversight concerns the scrutiny necessary to maintain the cost and schedule goals to achieve the agreed project scope. The US CMS Collaboration consults with the Director as part of the procedure for appointing the US CMS TD and CPM. The responsibilities of Fermilab are further described in a letter of joint appointment from DOE and NSF to the Fermilab Director. The Fermilab Deputy

Director will concur in the MOU between CERN and US CMS and in the MOUs between US CMS and the collaborating institutions

D. Fermilab Deputy Director

The Deputy Director is responsible for management oversight of the project. The TD and CPM report to the Deputy Director. The Deputy Director chairs the Project Management Group (PMG) which meets as necessary to monitor the progress of the project. Oversight of the project is implemented in part through reviews. Along with providing routine interactions with project management the PMG will identify actions and initiatives to be undertaken to achieve the goals of the project including the allocation of both financial and human resources. The Project Management Group will also function as the Baseline Change Control Board for the project.

To implement the work plan for the project, Memoranda of Understanding (MOU) with participating institutions are written assigning responsibilities and describing the work to be executed. The Deputy Director will concur in all Memoranda of Understanding. The Project Management Plan, the cost estimate, the schedule and the financial plan for the project require the approval of the Director and DOE and NSF with the concurrence of CMS and CERN.

E. Project Management Group (PMG)

The Department of Energy and the National Science Foundation request that Fermilab exercise management oversight for the US CMS detector project. A Project Management Group (PMG) will be convened by Fermilab for this purpose. It is expected that the PMG will include members from Fermilab, DOE, NSF and US CMS. The US CMS Spokesperson is also a member of the PMG, thus insuring that scientific issues will be communicated to the US CMS Collaboration. The PMG also serves as a high level Change Control Board. The PMG receives the reports of the US CMS Construction Project Manager.

F. US CMS Technical Director (TD)

The US CMS Construction Project Manager (CPM) and the US CMS Technical Director (TD) are co-leaders of the US CMS project. The CPM and TD serve as heads of the US CMS project organization whose project office resides in the Particle Physics Division at Fermilab. They consult regularly and keep each other fully informed of actions taken. The incumbents interact to draw on each other's strengths and one backs up the other when either is not available. The TD has provided leadership for the US CMS effort during its formative stage, has developed the management systems and will assist in their implementation. The effective operation of these management systems will provide critical information to both the TD and PM for managing the US CMS Project. The PM will apply his skills and experience in managing technical projects by

working with the TD to develop further the CMS technical, cost, and schedule baselines and other project documentation.

The US CMS Technical Director (TD) provides programmatic and technical coordination for the US consortium's effort to construct and commission the components for the CMS detector. This is outlined in the CMS protocol to the International Cooperation Agreement and specified in an international MOU agreed to by all the funding agencies involved in supporting the CMS project. The TD works with CMS to determine the scope of the US CMS contributions to the CMS detector. Scope changes from the baseline follow configuration change control procedures specified in this plan.

The TD represents the US CMS Project in interactions with CERN, DOE, NSF, Fermilab, and the universities involved. The TD represents the US CMS project within Fermilab and reports to the Director of Fermilab or his designee and through him to the DOE and NSF. The TD is jointly appointed by DOE and NSF and Fermilab.

The TD is responsible for ensuring that the technical goals of the project are appropriate and that they are achieved. The TD is the point of contact with CMS on scientific issues of scope and cost.

The TD assists in developing an integrated Cost and Schedule Plan and he will negotiate and approve the MOUs and annual Statements of Work for the project. The scope of the project is that proposed in the technical design report by the US CMS collaboration and adopted in the international MOU as well as any approved scope changes. In developing the MOUs and SOWs the TD has the authority to negotiate on behalf of US CMS with collaborating institutions and Fermilab Section and Division heads for collaboration or Laboratory resources.

The TD will approve the annual budget request made to the DOE and NSF, which is prepared by the CPM in a manner consistent with the Cost and Schedule Plan (CSP). The TD will maintain the L1 schedule, which interfaces to the CMS general planning.

Either the TD or the CPM may identify the need for project scope changes as they arise. When there is a need for a change having a significant impact on the physics capability of the detector they report this need to the Chairman of the PMG. When scope changes are considered the TD may receive technical advice from Internal Review Committees. The TD creates such committees as needed for technical advice and appoints their members in consultation with the US CMS EC and the CMS MB. The procedure for scope changes is described in Section VIII of this document.

The TD and CPM are jointly responsible for organizing presentations at reviews and status reports on the project in response to requests from the Fermilab Director or the funding agencies. The CPM and TD will initiate reviews of L2 subprojects to insure

that adequate progress is being made and that the subproject is meeting its technical performance, cost, and schedule milestones.

The CPM and TD have the authority to jointly appoint deputy and assistant managers and sub-Project Leaders (PL).

G. US CMS Construction Project Manager (CPM)

The US CMS Construction Project Manager (CPM) provides project management for the US consortium's effort to construct and commission the components for the CMS detector. This is outlined in the CMS protocol to the International Cooperation Agreement and specified in an international MOU agreed to by all the funding agencies involved in supporting the CMS project.

The CPM represents the US CMS Project in interactions with CERN, DOE, NSF, Fermilab and the universities involved. The CPM represents the US CMS project within Fermilab and reports to the Director of Fermilab or his designee and through him to the DOE and NSF as indicated in the project organization chart. The CPM is jointly appointed by DOE and NSF and Fermilab.

The CPM is responsible for completing the US CMS Project on the agreed upon schedule, and within the agreed upon budget and scope. He will establish and maintain an effective project organization to manage procurements, construction and commissioning of project components. The CPM is responsible for allocation of resources assigned to the US CMS project. The CPM has line management responsibility for ES&H issues associated with the US CMS project.

The CPM is responsible for preparing the Project Management Plan (PMP) and for updating it as necessary with the approval of the TD, Fermilab, DOE and NSF.

The CPM will develop an integrated Cost and Schedule Plan, and he approves the MOUs and annual Statements of Work for the project. The scope of the project is that proposed in the technical design report by the US CMS collaboration and adopted in the international MOU as well as any approved scope changes. The CPM has the authority to negotiate on behalf of US CMS with collaborating institutions and Fermilab Section and Division heads for collaboration or Laboratory resources. The CPM has authority to negotiate with all institutions for optimal utilization and management of these resources. The CPM has fiscal authority for US CMS project funds and is responsible for monitoring expenditures of these funds as well as tracking and reporting variances from baseline scope, schedule and cost estimates specified in the CSP.

The CPM is responsible for developing and presenting to the DOE and NSF the budget requirements for the project which are consistent with the CSP and he

determines the allocation of the funds available, including contingency funds and the management reserve.

Either the TD or the CPM may identify the need for project scope changes as they arise. When there is a need for a change having a significant impact on the physics capability of the detector they report this need to the Chairman of the PMG. When scope changes are considered the TD may receive technical advice from Internal Review Committees. The TD creates such committees as needed for technical advice and appoints their members in consultation with the US CMS CB and the CMS MB. The procedure for scope changes is described in Section VIII of this document.

The TD and CPM are jointly responsible for organizing presentations at reviews and status reports on the project in response to requests from the Fermilab Director or the funding agencies. The TD and the CPM will initiate reviews of L2 subprojects to insure that adequate progress is being made and that the subproject is meeting its technical performance, cost, and schedule milestones.

The CPM and TD have the authority to jointly appoint deputy and assistant managers and sub-Project Leaders (PL).

H. Level 2 Managers (L2M)

The WBS Level 2 Managers (L2M) are appointed by the US CMS TD and CPM. The L2M are members of the PMG. They have the specific responsibilities listed below:

- Define the WBS work scope
- Estimate work scope cost
- Schedule the work scope
- Time-phase cost estimate (integrate cost estimate to schedule)
- Determine schedule progress as the end of each month
- Validating earned value for each
- Determine/validate monthly actual costs
- Evaluate monthly and cumulative-to-date budgets, earned value, and actual costs
- Accomplish analysis and take corrective action accordingly
- Analyze each month the cost and schedule variances provided by the Project Office
- Take corrective actions to meet technical, cost, and schedule
- Planning and managing the design, construction, installation, and commissioning of their respective subsystem projects
- Serving as the cost/schedule manager for all WBS elements in their subprojects
- Participating in project planing and costing
- Managing cost estimating for their subsystem
- Participating in project planning, scheduling, and accessing work accomplishments

I. Project Cost and Schedule Manager

Project Cost and Schedule Manager reports to the CPM and is responsible for the operation of the Project Management Control System including:

- Maintenance of the baseline cost estimate
- Maintenance of the baseline schedule
- Monthly updating of project office schedule progress from the Level 2 Managers
- Monthly collection of project actual costs
- Production of monthly Cost and Schedule Status Report
- Analyzing actual cost reports from the participating laboratories for correctness of charges
- Assisting the Project Office and Level 2 Managers in budgeting.

J. US CMS Project Office

1. Fermilab as US CMS Host Institution

Fermilab has agreed to act as host laboratory to the US CMS Project, and will also serve as the location of most project reviews. The US CMS Project Office will physically reside at Fermilab, and will provide administration for DOE funds. (Administration of NSF funds is provided by the US CMS NSF Office; see below.) Fermilab will also provide Service Accounts for US CMS groups, and travel and purchasing support will be available.

Use of Fermilab facilities and services shall be agreed upon via MOU in the same manner as with the use of available infrastructure at any US CMS institution. The L1M must report to the Fermilab Deputy Director to provide accountability for all services provided by Fermilab to US CMS which are not paid for by US CMS Project funds. The provided services may include services provided to the Fermilab CMS group or may be services provided to other US CMS Institution. Within the framework of the MOU specific items shall be negotiated annually by Fermilab (as host laboratory), by the US CMS TD and CMP, and by the collaborating US CMS institution.

2. Allocation of Funds

The CPM annually determines the allocation of funds to US CMS institutions with advice from the TD. Subsequently, purchase orders are issued to those institutions (including Fermilab as a US CMS collaborating institution). Explicit arrangements are defined in the US CMS MOU and annual SOW, which appear in Appendices A and B.

The organization of the US CMS Project Office is shown schematically in Fig. III-1. The US CMS Level 1 Managers head this office. Allocations of project funds are the

purview of the Project Manager with the scientific advice of TD. All costs of the Project Office (exclusive of physicist salaries) shall be explicitly borne by the US CMS Project and are called out in the US CMS WBS.

3. Management Reserve and Funding Allocation

The Project Manager shall hold a management reserve each fiscal year. That reserve will be committed by the Project Manager during the course of the year based on performance and need of the various groups in the US CMS Collaboration. The reserve will be allocated to individual US CMS institutions in the same manner as the main fiscal year allocation.

4. US CMS NSF Office

The US CMS NSF Coordinator shall maintain an office responsible for the administration of NSF funds. The NSF Coordinator is appointed by the NSF upon the recommendation of the NSF-funded CMS institutions, and serves as the NSF Liaison on the CMS Finance Board. The NSF Coordinator is a member of the PMG.

5. Support and Programmatic Organization

The US CMS Project Office will draw on Fermilab resources as agreed by the Fermilab Director. The use of these resources will follow procedures consistent with the Laboratory's current accounting, budgeting, human resources, and procurement department policies. The Project will obtain support to the extent agreed from the Laboratory's indirect support group, including:

- Accounting and Budgeting
- Environment, Safety and Health
- Human Resources
- Legal and Material
- Facilities Management
- Quality Assurance
- Information Services

All support functions will be provided through the Laboratory matrix organizational lines of authority and responsibility. The US CMS Project Manager will direct all questions of priority need for Laboratory support assistance not satisfied through normal lines of authority to the Laboratory Deputy Director.

6. Review Committees

Review Committees provide a means for the Level 1 Managers to review technical, cost, and schedule issues for L2 subprojects. These committees may also be

charged with reviewing the physics performance of the subsystem or recommending scope changes to CPM and TD. Review Committees are appointed from the CMS membership as required. The CPM and TD charges them, in consultation with the PMG. Reports and recommendations from review committees are transmitted to the L2 Managers and are in general made available to the entire US CMS collaboration.

7. Subproject Technical Committees

There may be technical committees associated with a subsystem and separate from the US CMS internal review boards discussed above. The L2 manager as needed appoints these. Members of such technical committees advise the subsystem L2 managers on technical directions, alternatives, and methods of performance. The members of the committee would include scientists responsible for the design and fabrication of the subsystem or of major tasks within it. Other technical experts may also be included. The L2 manager appoints the members of sub-project technical committees. These committees act in an advisory capacity. Decision authority remains in the hands of the L2 manager consistent with the line responsibility described above.

8. Project Communications

The US CMS Project necessarily entails coordination between CERN, Fermilab, DOE and NSF. At the experiment level, CMS must coordinate with the US CMS collaboration. The US CMS Project is conducted as a team effort involving DOE, NSF, CERN, Fermilab, CMS and US CMS. For the Project to progress, all parties need to be fully informed of progress, plans, issues, problems, solutions, and achievements in real time.

Communication among participants is free and informal to the maximum extent feasible. Notes, "drafts," phone calls, electronic mail, and informal discussions are exchanged frequently among the participants to accomplish information flow, raise issues for mutual resolution, and explore the viability of plans and solutions. Distribution of copies of informal correspondence to all participants is desirable to keep them fully apprised of these communications. Each organizational participant should designate an individual to coordinate informal communications and to assure their proper distribution within that organization.

Section IV

Work Plan

IV. Work Plan

A. Introduction

In this chapter, the work to be performed in the US CMS Project is described in Section IV.B, and the methodology to be used in the execution of the work is described in Section IV.C. The research and development (R&D) program connected with the US CMS Project is described in Section IV.D. System tests and commissioning are discussed in Section IV.E. The final two sections of this chapter describe the programs to be utilized by the US CMS Project for Quality Assurance (Section IV.F) and for Safety Analysis and Compliance and Environmental Compliance (Section IV.G).

B. Work Description

This project provides for the construction of elements of an experiment to be performed at CERN, designated the US CMS Project. The purpose of the project is described in Section II.A. The salient features of the work that needs to be done are briefly described in Section II of this plan, and in considerable detail in the CMS Technical Design Reports.

C. Research and Development Program

A program of R&D in support of the US CMS construction project has already been initiated. This program will provide for the design and development of new detector components and for the fabrication and testing of prototypes. R&D directed towards the optimization of performance and cost will continue through the early years of construction. The DOE funded efforts in R&D will be done largely in FY96 and FY97. The NSF funded effort has and will occur in FY96, FY97, and FY98. The scope of the FY96 efforts in R&D undertaken by the US CMS collaboration are discussed in the US CMS Project Status Report, (October, 1996). The R&D program has been developed to interface with the construction project milestones.

D. Quality Assurance Program

Quality assurance is an integral part of the design, procurement, fabrication, and construction phases of the US CMS Project. Special attention is being devoted to items that will affect the performance capability and operation of the CMS detectors.

It is the policy of the US CMS project that all activities shall be performed at a level of quality appropriate to achieving the technical, cost, and schedule objectives of the project. To implement this policy, the US CMS project will develop a standard quality implementation plan that is based on the QA criteria established by DOE and NSF. The responsible person for the QAP for the US CMS is the US CMS Project Manager.

The US CMS project SQIP will define the management policies in regard to 1) QA program, 2) Personnel Training and Qualification, 3) Quality Improvement, 4) Documents and Records, 5) Work Processes, 6) Design, 7) Procurement, 8) Inspection and Acceptance Testing, 9) Management Assessment, and 10) Independent Verification.

Vendors will implement quality assurance programs appropriate to the services being furnished. As specified in the MOU, US CMS activities done at each institution will use the implemented quality assurance programs. All these programs, as well as implementing procedures, are subject to review and audit by the US CMS Project Office at Fermilab.

Section V

Work Breakdown Structure

V. Work Breakdown Structure

All work required for successful completion of the US CMS Project is organized into a Work Breakdown Structure (WBS). The WBS contains a complete definition of the scope of the project and forms the basis for planning, execution, and control of the US CMS Project. The US CMS WBS is continued to a sufficiently low level to make each deliverable and its provider unique and trackable. Specifically, the WBS provides the framework for the cost estimating, scheduling, and budgeting.

The Project Summary WBS is a consolidation of the top three levels of the US CMS Construction Project WBS. The sample US CMS Construction Project WBS is as follows:

- 1 Endcap Muon**
 - 1.1 Cathode Strip Chambers
 - 1.2 Electronics
 - 1.3 Mechanical structure
 - 1.4 Installation
 - 1.5 Slow Control
 - 1.6 Services
 - 1.7 Alignment
- 2 Hadron Calorimeter**
 - 2.1 Barrel Hadron Calorimeter
 - 2.2 Outer Barrel Calorimeter
 - 2.3 Endcap Hadron Calorimeter
 - 2.5 Forward Calorimeter
- 3 Trigger and Data Acquisition**
 - 3.1 Trigger
 - 3.2 Data Acquisition
- 4 Electromagnetic Calorimeter**
 - 4.1 Barrel Photodetectors
 - 4.2 Electronics
 - 4.3 Monitor
 - 4.4 Crystal Development
- 5 Forward Pixels**
 - 5.1 Readout system
 - 5.2 Sensors
 - 5.3 Mechanical and Cooling
 - 5.4 Final assembly and testing
 - 5.5 Tests
 - 5.6 Software
 - 5.7 Project Management
 - 5.8 Installation at LHC

- 6 Common Projects**
 - 6.1 Pack A, Barrel Yoke and Vac Tank (23.3)
 - 6.2 Pack B, Endcap Yoke (18.0)
 - 6.3 Pack C, Superconductor (16.9)
 - 6.4 Pack D, Coil Winding (15.3)
 - 6.5 Pack E, CERN- power, He refrig, etc.(9.3)
 - 6.6 Pack F, In kind (1.8)
 - 6.7 Pack G , Common Funds(37.3)
 - 6.8 Common Project Software(3.6)
- 7 Project Office**
 - 7.1 Baselineing
 - 7.2 Tracking
 - 7.3 Reporting
 - 7.4 PO Support
 - 7.5 NSF PO Branch at NEU
 - 7.6 Programmatic Travel

The levels of the WBS reflect the logical breakdown of the work required to complete the project with lower levels providing progressively higher levels of detailed description. The number of levels is established by extending the description down to a level at which individual components (typically costing or an order of \$10k) can be identified and associated into a well-defined piece of equipment or structure.

The detailed activities to design, build, and commission the US CMS are described in the WBS Dictionary and/or in the Basis of Estimates. Each element of the WBS has cost, manpower, and schedule associated with it and is the key element for planning and controlling cost and schedule.

Changes to parameters are controlled by a Change Control System. The impact of any such change on the associated cost, schedule, and WBS dictionary will be evaluated by the appropriate Change Control Board. The Cost and Schedule Manager is responsible for maintaining the current cost, schedule and dictionary and the records of all changes. All changes must be approved at the appropriate level prior to implementation. Once the approved, the changes will be implemented in the WBS, WBS Dictionary, baseline budget, estimate to complete, schedule, etc. as required.

A. Cost Estimating

The WBS supports a systematic approach to preparation of the cost estimate for the project. The WBS structure is extended to a sufficient level of detail to allow definition of individual components for which a cost can be reasonably estimated. The budget and cost estimate are equal for the lowest level in each branch of the WBS when the baseline is approved.

B. Scheduling

The WBS also supports a systematic approach to preparation of the project schedule. Again each WBS element at the lowest level of the structure is assigned a schedule duration. Establishing the interdependencies between the various elements creates the project schedule.

C. Budgeting

The schedule is then “resource loaded” by spreading the cost estimate over time to reflect the work plan. This provides each element of the WBS at the lowest level a budgeted cost of work schedule (BCWS). The budget of the project can be seen at any level by performing a summary over contributing lower levels. Budgets are formal statements of the financial resources set aside for carrying out specific activities in a given period of time and comprises inherently the following:

- The budget reflects US CMS financial plan, which represents the goals of the Project Management Plan
- The budget is expressed in time-phased quantifiable or measurable terms, so that status along the way can be determined
- All Level 2 components of the organization will be made aware of their portion of the overall budget
- Performance against the budgets will be monitored and reviewed monthly with project management

D. WBS Support Requirements and Dictionary

The WBS, in conjunction with the associated resource loaded schedule provides the framework for projecting funding and manpower requirements over the life of the project. The WBS Level 2 Managers are shown in Table V-1. The L2 managers are required to provide the CPM a detailed WBS dictionary of their subsystem. This dictionary and the basis of estimate provide the documentation, which defines the quality of the estimated costs for the project.

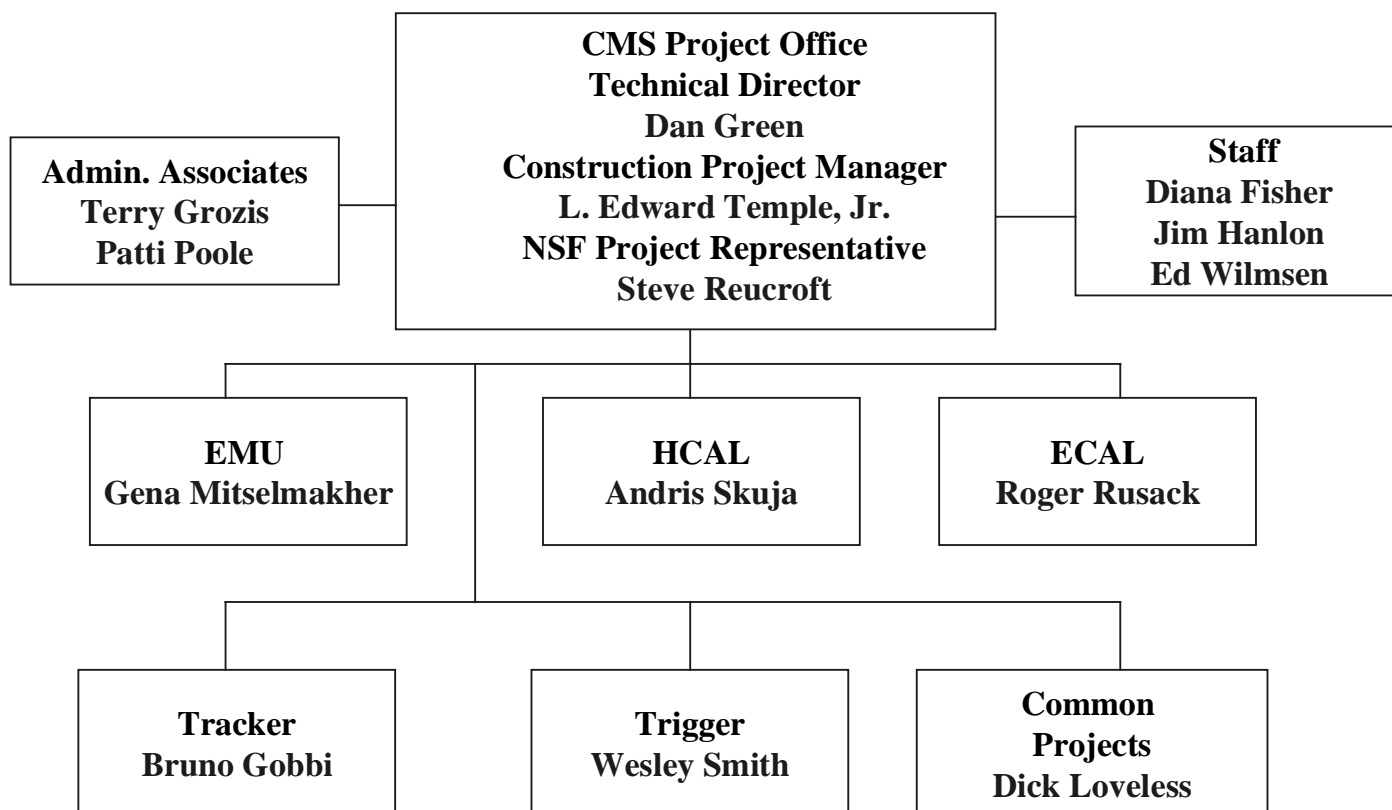
E. Performance Measurement

The WBS supports the monitoring, control, and reporting of cost and schedule performance. Since each element of the WBS, and by association each work element, has a well-defined budget and schedule a view of the progress of the project at any level is available at any time. Taking the actual costs (actual costs of work performed (ACWP)) and planned budget comparing it to the work performed known as earned value (Budget Cost of Work Performed (BCWP)) for the cost and schedule variances for current month, cumulative to date and at completion.

F. Management Review, Corrective Actions, and Change Request

The detailed scope of the project is contained within the WBS and described in the WBS Dictionary. After management has been apprised of the status of their budget/actuals versus work accomplished to date, there this may surface any corrective actions for management's review for decisions to be taken, (i.e., descoping work, issuing contingency, etc.) to keep on an acceptable budget and scheduling path. Proposed changes to the scope can readily evaluated within the WBS framework.

US CMS PROJECT SUMMARY WBS



US CMS PROJECT AND WBS LEVEL 2 MANAGERS

FIG. V-1

Section VI

Project Schedule and Milestones

VI. PROJECT SCHEDULE AND MILESTONES

A. Schedule Baseline

The CMS Construction Schedule provides the master schedule for construction. The schedule baseline sets forth the major activities, decision points and activity interfaces essential for completion of the US CMS Project. The baseline schedule includes interpretation and optimization of activities related to the design, procurement, fabrication, assembly, testing, installation and checkout of detector elements. The Project Master Schedule will be developed to include major activities and decision points. It is composed of major WBS level 3 elements with significant milestones included. This schedule will be the top-level project schedule and is the basis for baseline development in all-lower level project schedules.

Work package schedules at the lowest WBS level (L7) will be assembled into an interconnected activity logic diagram by integrating construction activities within each respective WBS element. Schedule interfaces with other WBS elements will be made. This integrated schedule provides a total project critical path. Summarization of these lower level activities allows status to be rolled up through the various WBS levels to provide intermediate level and master level working schedules. These working schedule dates are compared to the established baseline dates and any variances addressed in the Progress Reports. Consistency of data from work packages through intermediate schedules to the master schedule will be traced through control and event milestones. All milestones contained in the Project Master Schedule are reflected in the lower level schedules.

The schedule management and monitoring system will be developed using Microsoft Project a software tool available at Fermilab and one adopted by CMS. The schedule status is summarized at the various WBS levels, to provide project schedule reporting at the master, intermediate, and detailed levels by WBS and across functional organizations. The master level schedule will also include a critical path, defined by the CPM by considering the critical paths of each of the L2 efforts.

B. Baseline Milestones

A set of project milestones for L1 schedule has been defined by the US CMS Collaboration, in consultation with CMS. The L1 schedule for US CMS and the corresponding CMS milestones appear in the CMS MOU. The L2 managers provide subsystem schedules, which are then linked to the L1 milestones. This linked US CMS schedule is then resource loaded in order to provide a US CMS cost profile. CMS has adopted Microsoft Project as the management software, and US CMS has followed that decision.

Section VII

Cost and Labor Estimates

VII. Cost and Labor Estimates

A. Cost Baseline

The cost baseline will be established when the Project Plan is reviewed. The project cost baseline is equal to the sum of the budgeted costs for each element of the Work Breakdown Structure described in Section V. Changes in cost, technical requirements, schedules, and plans are to be treated as variances to the baseline.

The TPC is \$167,245K that includes \$14,485K of escalation, and \$7K of R&D. This total should not will be exceeded. The TEC of the US CMS project is \$145,756K in FY 97 dollars. Included in the TEC are procurement, assembly, and installation of all technical components, engineering design, inspection, and project management required to assure successful completion of the project. Contingency funds in the amount of 43% of the base cost, excluding common projects, are also included in the TEC.

WBS Number & Description	Base Cost (k\$)	Cont (k\$)	Cont (%)	Total Cost (k\$)
US CMS Total Project Cost (then-year dollars)				167,245
Escalation (DOE January 1998 indices)				14,485
FY97 R&D				4,640
FY96 R&D (FY97 dollars)				2,364
US CMS Total Estimated Cost (FY97 dollars)	101,976	43,779	43	145,756
1 Endcap Muon	24,190	10,955	45	35,145
2 Hadron Calorimeter	27,624	12,954	47	40,578
3 Trigger and Data Acquisition	10,915	5,712	52	16,627
4 Electromagnetic Calorimeter	7,153	3,579	50	10,732
5 Forward Pixels	4,677	3,028	65	7,704
6 Common Projects	22,249	5,522	25	27,770
7 Project Office	5,170	2,030	39	7,200

B. Obligations and Cost Plans in FY 1997 Dollars

The construction cost estimate is maintained in fixed year (FY 1997) dollars. The TEC in FY 1997 dollars is \$145,756K.

C. Escalation

Escalation rates are based upon an assumed annual escalation rate given by guidance from OMB.

D. Budget Authority and Funding Profile

The project baseline schedule, obligations and cost plan will be based on the best estimate of the funding profile. The obligation plan will be derived from the baseline schedule and cost plans given in this Project Management Plan. Similarly, application of the escalation rates given in C above will result in the cost plan.

E. Labor Requirements

Labor requirements have been estimated for each work package in the US CMS project. These estimates include the required EDIA and Fermilab-based project management, as well as manufacturing labor.

Section VIII

US CMS

Cost/Schedule

Control System

(C/SCS)

Section IX

Reporting And Review

Appendix A.

Memoranda of Understanding will exist both within the CMS collaboration as a whole, and for the US CMS collaboration.

A Memorandum of Understanding (MOU) is negotiated between CERN as the host laboratory, the collaborating CMS institutions (represented by the CMS Collaboration Board) and their funding agencies (DOE and NSF in the US). A draft of an Interim MOU covering the initial phase of the CMS experiment has been signed for the 1996 and 1997 period of R&D.

Within the US CMS Project, a US MOU will be executed. Draft versions of this MOU and of the annual SOW have been written, and appear here as Appendices A and B. The signatories of this MOU are threefold: Fermilab as host laboratory, the US CMS collaborating institution, and the US CMS CPM. By means of the MOU agreement the L2 managers and the US CMS Project Manager will identify the work to be done at each member institution of US CMS, together with the necessary resources. It will also establish reporting to be done by each institution of both financial and schedule milestones.

DRAFT

Memorandum of Understanding Between

<Institution>

and

**US CMS Collaboration
Project Management
at Fermilab**

<date signed>

1. Introduction

This Memorandum of Understanding (MOU) describes the collaboration by members of <Institution> in the Compact Muon Solenoid (CMS) Project in the United States. The purpose of this collaboration is the design, fabrication, operation and scientific exploitation of the CMS Detector. The detector is described in the CMS Technical Proposal, December 15, 1994, the Technical Design Reports, and subsequent technical documents elaborating that design. The contribution of the US CMS Collaboration to the CMS Detector Project is defined by the scope of work set out in the US CMS WBS and accepted as the baseline set of deliverables by DOE and NSF. This scope of work forms the basis of the MOU between CERN and DOE/NSF.

The US CMS project management infrastructure (US CMS Project Office) resides at Fermilab, and the responsibility for US CMS project management resides in the US CMS Technical Director (TD) and Construction Project Manager(CPM) who report to the US CMS Fermilab Project Management Group (PMG) and the Fermilab Deputy Director. The US CMS TD/CPM have appointed level two (L2) managers who are responsible to them for subsystems of the US CMS project.

This Memorandum of Understanding describes the long-term contributions of <Institution> to the design, construction and operation of the CMS Detector. It is understood that these contributions of <Institution> may later be modified or that additional responsibilities may be added. The US CMS project finishes at the end of FY2004.

An annual Statement of Work (SOW) will detail the contributions of <Institution> as the detector construction proceeds and will contain the specific activities, deliverables and funding required. The normal period of performance will be the US fiscal year (October 1-September 30). A separate SOW will be written for each L2 subsystem, while the MOU will be a single document for each US CMS Institution. In FY98 SOWs were written with all institutions then participating in the project.

This Memorandum of Understanding is made between <Institution>, the US CMS TD/CPM and Fermilab as part of its role in management oversight. It does not constitute a legal contractual obligation on the part of any of the parties. It reflects an arrangement that is currently satisfactory to the parties involved. The parties agree to negotiate amendments to this memorandum as required to meet the evolving requirements of the CMS detector construction program.

2. Personnel

2.1. List of Scientific Personnel

Participating scientists committed to CMS over the full project period are listed below. No support for these individuals comes from project funds.

Name	CMS Fraction*	Other Research Commitments/Comments

*Time devoted to CMS over and above the indicated CMS research fraction is considered to be <Institution> service effort in support of CMS.

2.2. Collaboration Board Representative

<Name> is the present representative of <Institution> to the US CMS Collaboration Board.

2.3. List of Technical Personnel

Participating technical personnel with the anticipated fraction of their time (time fractions are estimates and are not cost shares) committed to CMS during this period of performance and their source(s) of support are indicated below. The possible sources are DUS = DOE, US CMS Project; NUS = NSF, US CMS Project; DBG = DOE base grant; NBG = NSF base grant, UID = university infrastructure, DOE-supported group; and UIN = university infrastructure, NSF-supported group as shown in the WBS.

Engineers

Name	CMS Fraction	Cost on CMS Project	Source of Support

Designers

Name	CMS Fraction	Cost on CMS Project	Source of Support

Technical Specialists

Name	CMS Fraction	Cost on CMS Project	Source of Support

Programmers

Name	CMS Fraction	Cost on CMS Project	Source of Support

Others

Name	CMS Fraction	Cost on CMS Project	Source of Support

2.4. Other Key Personnel

The Environment, Safety and Health officer for <Institution> currently responsible for compliance with applicable ES&H policies associated with CMS participation by this institution is <ES&H Name> of <Institution>. The Quality Assurance officer for the US CMS group at <Institution> currently responsible

<Institution> responsible for QA compliance of tasks performed by this institution is currently <name> of <Institution>. [Persons identified in this section are typically ES&H and QA professionals who provide assistance to line personnel responsible for CMS activities.]

3. Design, Fabrication and Installation Responsibilities**3.1. Design and Fabrication Responsibilities - Construction Period****3.1.1 *WBS Items at L2, Estimated Cost and Deliverable:***

The US CMS Work Breakdown Structure (WBS) contains a detailed cost estimate of the items needed to complete the US CMS project. By this MOU <Institution> agrees to make a best effort to provide the following items at a cost not to exceed the WBS base cost estimate. Procedures to be followed in the event of a necessary variation of cost from the base cost are described in section 3.3 below. The table below lists the WBS summary items at L2. Appendix A gives the full WBS breakdown of the items to L7.

WBS (L2)	Task - Deliverable	WBS Base Cost	Cost at this instit	FNA L MPO	DOE Suppl .	NSF
Total	Requested Project funds (\$k)	---				

3.1.2 *Transportation*

Unless specifically indicated otherwise here, items produced by <Institution> for use in the CMS detector or subsystems shall be transported by the providing institution to the agreed upon point of delivery. <Institution> shall be responsible for safe transport of all items to these delivery points. The method of transport and packaging are to be authorized by the US CMS Project Office in consultation with the appropriate L2 lead engineer..

3.1.3 *Installation and Commissioning*

<Institution> will participate in the installation and commissioning of their contributed items at CERN as listed. The <Institution> will also participate in the maintenance and operation of these items.

<Item 1>
<Item 2>...

3.2. Coordination and Reporting

The US CMS L2 manager for the <subsystem> subsystem is <name1>. The institution contact person for <subsystem> activities at <Institution> is <name2>. The task managers for <subsystem> activities carried out at <Institution> are as follows

Task	Task Manager
------	--------------

The progress of the design, fabrication, and testing of these components will be reported by the above-named task managers on a monthly basis, by WBS element to L3 in detail, to the US CMS L2 Manager, who in turn will report subsystem progress to the US CMS TD/CPM. The TD/CPM will, in turn, report to the Fermilab PMG.

Technical reporting to CMS project management will be performed by the US CMS Subsystem Coordinator. Financial reporting to CMS will be made by the US CMS CPM.

3.3. Procurement Authorization

The authorized financial officer at <Institution> is <name>. The US CMS TD/CPM delegate expenditure authority regarding the designated WBS items in the SOW to the authorized financial officer subject to the following requirements. The base cost of the WBS items is given in section 3.1.1 without contingency. The officer agrees that these cost ceiling cannot be exceeded without the authorization the TD/CPM and the relevant L2 manager. In addition, the officer agrees that item purchases exceeding the delegated limit (currently 10 k\$) must be authorized by the US CMS L2 manager.

Major procurements (currently 100 k\$) must in addition have the written authorization of the US CMS TD/CPM. Items purchased as CMS Common Project items (WBS category 6) must be explicitly authorized by the US CMS TD/CPM and approved by the CMS Finance Board Chair, regardless of the cost. Items purchased for Project Office (WBS category 7) must be authorized by the TD/CPM.

3.4. Reporting to US CMS Project Management

<Institution> will report all CMS related expenditures and labor charges together with associated technical progress in each item of work by Work Breakdown Structure (WBS) category (Level 7) on a monthly basis through the appropriate US L2 Manager(s) to the US CMS TD/CPM. Cost reporting will apply to US CMS Project funds related to detector fabrication. Other, non-DOE and non-NSF costs will be reported in a manner that is agreed to by the L2 Manager(s), the US TD/CPM and <Institution>. Any request for variance from the base cost must be immediately reported to the appropriate L2 manager.

Technical progress will be reported by WBS element L4 to the L2 Manager and the TD/CPM on a monthly basis and will cover all items covered in this Statement of Work regardless of the specific nature of the funding support.

The <institution> agrees to furnish complete documentation of the quality control and performance checks which are carried out for US CMS. Further, the institution agrees to furnish full documentation of all equipment and services which it provides for the US CMS project. This will include engineering drawings of equipment, full schematics of electronics, and documentation of all software. Where relevant, an acceptable level of spares (~10%) will be provided and maintained by the institution.

Each US CMS group at <Institution> agrees, with this document, to set up and maintain a ledger, of a form specified by US CMS Project Management. This ledger will contain information on cost items at L7 of the US CMS WBS. Each Institution agrees to provide and maintain this ledger so as to provide timely information to the L2 Manager and the US CMS TD/CPM.

3.5. Collaboration with Other Groups and Institutions

Design, construction and installation related to the <subsystem> subsystem will be carried out in close communication and collaboration with other groups working on this and related subsystems.

WBS / Task (L4)	Collab. Group	Responsibility with <Institution>

4. **Contribution of Effort, Services and Equipment**

4.1. Effort

Subject to funding by DOE or NSF, <Institution> will provide support for the scientific and technical personnel as indicated in section 2. This contribution refers only to support provided outside the US CMS Project.

4.2. Services

The services of the <Institution> Purchasing, Expediting, and Receiving Departments and the Administrative Staff will be available to the CMS project to the

degree required to carry out the fabrication responsibilities of <Institution>. By this MOU, <Institution> agrees to provide the services of the responsible financial officer.

4.3. Facilities and Equipment

The following <Institution> facilities and equipment will be made available to the CMS project to the degree necessary to carry out the design and fabrication responsibilities of the group:

Facilities and Equipment:

4.4. Operating Costs

<Institution>, subject to the availability of funds from DOE or NSF, will support the normal research operating expenses (such as physicists' salaries, travel expenses, miscellaneous supplies, administrative support, etc.) of the <Institution> group working on the CMS project. These normal operating expenses are not considered as part of the CMS detector cost estimate nor will they be borne by the US CMS project.

5. **Fermilab (as host institution) Effort, Services and Facilities**

Tracking of Fermilab CMS support, whether provided by Fermilab or paid by the US CMS Project, will be done using appropriate effort reporting codes. The costs incurred will be reported to the Fermilab Director.

Subject to agreement, to be negotiated annually with the Fermilab Director, <Institution> expects the following Fermilab resources to be available in support of <Institution's> design, fabrication, and installation responsibilities:

5.1. Administrative and Technical Personnel

Participating Fermilab staff members foreseen to be available to the project are:

Administrative Staff

Name	CMS Fraction	Source of Support

Engineers

Name	CMS Fraction	Source of Support

Designers

Name	CMS Fraction	Source of Support

Technical Specialists

Name	CMS Fraction	Source of Support

Programmers

Name	CMS Fraction	Source of Support

Others

Name	CMS Fraction	Source of Support

Administrative and technical staff salary support may be paid by the US CMS Project, or may be provided by Fermilab as project host. The salary support of Fermilab staff contributing to <Institution's> responsibilities must be negotiated annually with the Fermilab Director as part of the SOW. Support provided by Fermilab will be tracked and reported to the Fermilab Director and the PMG.

5.2. Services

The services of the Fermilab Purchasing, Expediting, and Receiving Departments are expected to be available to <Institution> for the procurement of the following items:

<Item 1>
<Item 2>...

5.3. Facilities and Equipment

<Institution> expects that the following Fermilab facilities, equipment, and laboratory space will be available during the course of the project:

Facilities, equipment, and laboratory space:

6. Costs and Funding**6.1. Expected Sources of Funding**

The cost of the detector elements covered under the US CMS WBS are taken in detail from the current US CMS Cost Estimate (<Date>). DOE (NSF) Funds indicate the project funds expected to be provided over the lifetime of the project. <Institute> agrees to not exceed the costs shown above, estimated cost less contingency, subject to the procedures given in section 3.3.

6.2. Management Reserve

Each year, a SOW will be written with each US CMS Institution for each L2 subsystem which is relevant. The allocation of funds for the fiscal year will be in two parts. The first will cover work for the first six months. The remaining funds needed to complete the tasks described in the SOW will be provided subject to availability of funding and performance during the first half year. Management control requires the review and concurrence of the L2 Manager and the TD/CPM, as needed, for major expenditures, as defined above. The release of funds above the given thresholds by the responsible financial officer as named above will be contingent upon this concurrence.

7. **Method of Funding Transfers**

The expenditures by <Institution> are to be covered by funds provided by DOE or NSF, upon the allocation decision of the US CMS TD/CPM with the concurrence of the US CMS Fermilab PMG.

Funds to cover work or expenditures described in this document may be provided directly to <Institution> by DOE or NSF, or by subcontract from the US CMS Project Office at Fermilab. The choice of funding method shall be at the option of the TD/CPM.

All equipment items bought or fabricated using DOE or NSF funds will be properly marked as the property of DOE or NSF. Any other equipment furnished by <Institution> as part of the detector will remain <Institution> property. In either case, the equipment will remain part of the CMS detector until it is dismantled or the detector element in question is replaced.

8. **General Considerations**

8.1. Safety and Engineering Practices

The experimenters from <Institution> agree to familiarize themselves with DOE and NSF safety policies and to adhere to them. All detector components must be designed, fabricated, installed and operated in conformity with DOE, NSF and CERN safety policies and practices as well as DOE, NSF and CERN engineering standards. All

engineering, design, quality assurance, safety, and other activities shall be in compliance with ISO standards. All major components will undergo appropriate design, safety, and engineering reviews.

8.2. Operations

<Institution> agrees to maintain, to the best of their ability, equipment provided for the CMS detector as long as <Institution> is a member of the CMS collaboration.

9. Schedules and Milestones

<Institution> will make every effort to carry out their institutional responsibilities consistent with the schedule for the fabrication of the CMS detector. These schedules may have to be changed as the project progresses. Changes that affect <Institution> will be noted in the annual SOW. The program milestones over the life of the project relevant to <institution> are listed here:

Program Milestones	Baseline Milestone Date	Current Milestone Date

10. Makers and Concurrence

The following persons concur in the terms of this Memorandum of Understanding. These terms will be updated as appropriate in Amendments to this Memorandum.

Makers of this Memorandum:

_____ Dan Green US CMS Technical Director	date	_____ Administrative Officer <title> <Institution>	date
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_____ Ed Temple US CMS Construction Project Manager	<date>	_____ <Name> Grants/Contracts Officer <Institution>	<date>
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_____ <Name> US L2 Manager <Subsystem> Subsystem	date	_____ Principal Investigator <Name> <Institution>	date
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_____ <Name> US L2 Manager <Subsystem> Subsystem	date	_____ Principal Investigator <Name> <Institution>	date
---	------	--	------

_____ <Name> US L2 Manager <Subsystem> Subsystem	date	_____ Principal Investigator <Name> <Institution>	date
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_____ <Name> US L2 Manager <Subsystem> Subsystem	date	_____ Principal Investigator <Name> <Institution>	date
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Concurrence:

Ken Stanfield
Deputy Director
Fermilab

<Name>	date
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Copy sent to:

Ernst Radermacher date
CMS Technical Coordinator
Fermilab

Appendix A – WBS Cost Estimate at